New Zealand's Changing Climate + Oceans

Auckland Conversations
12th December 2013

Sir Peter Gluckman

OFFICE OF THE PRIME MINISTER'S SCIENCE ADVISORY COMMITTEE

New Zealand's changing climate and oceans: The impact of human activity and implications for the future

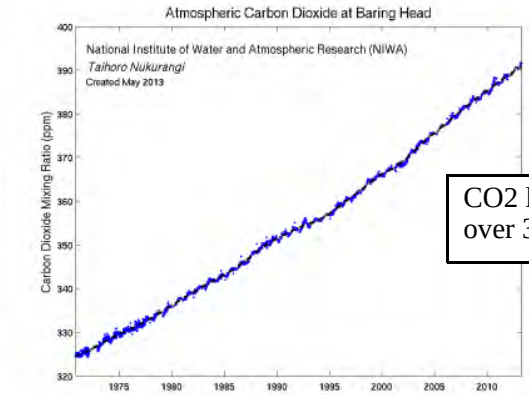
An assessment of the current state of scientific knowledge by the Office of the Chief Science Advisor

http://www.pmcsa.org.nz/wp-content/uploads/New-Zealands-Changing-Climate-and-Oceans-report.pdf

NZ Observations

New Zealand has a long history of monitoring our environment, e.g...

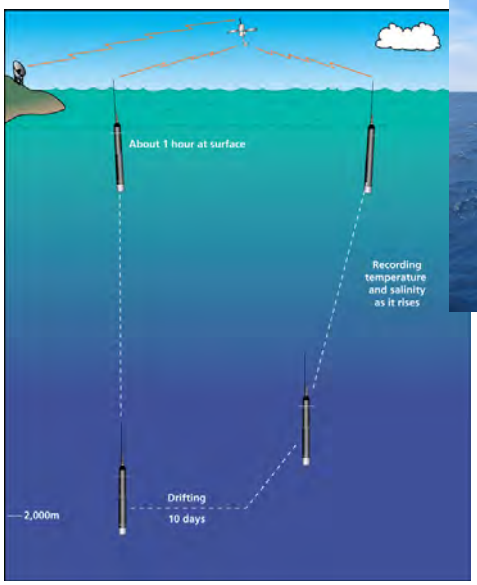
Baring Head – Greenhouse gas monitoring

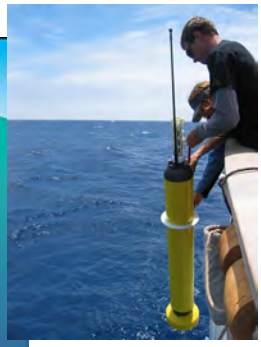


CO2 levels now over 390ppm

Back in 1973: CO2 level was 320ppm

Deploying ARGO floats to monitor temperature + salinity of the ocean

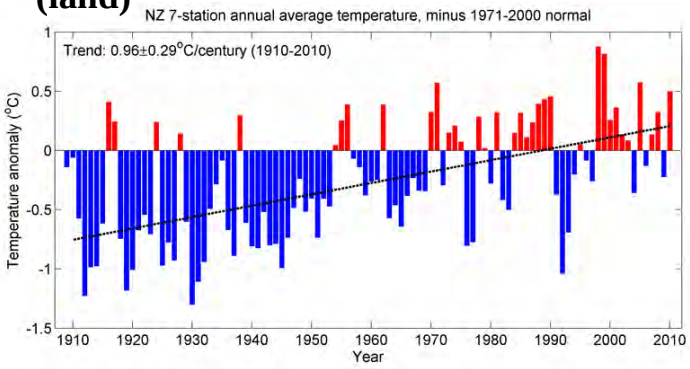




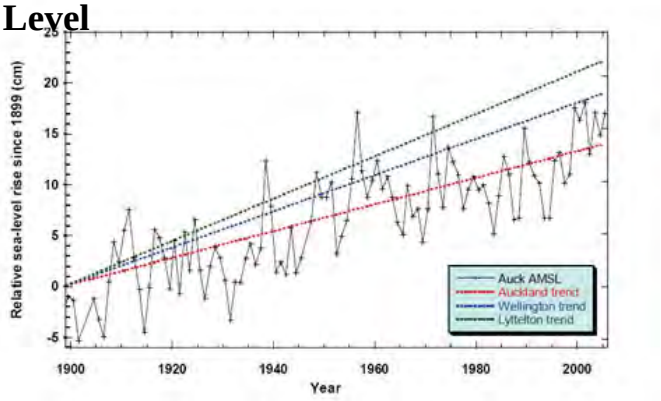
Source: NIWA

Changes have already been observed in NZ

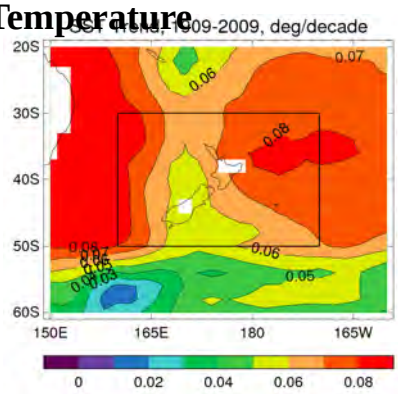
Annual Average Temperature (land)



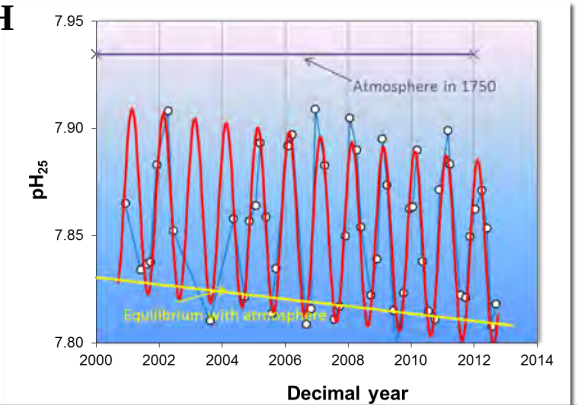
Sea Level



Sea Surface Temperature



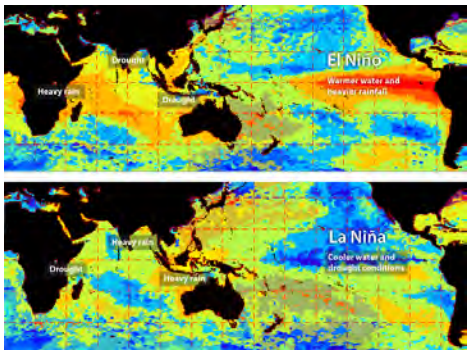
Ocean pH



Natural Variation

	Annual and Inter-annual	Inter-decadal e.g.s	10,000 yr+
Ocean-atmosphere interaction	El Nino/Southern Oscillation (recurrence time 2-2.5 years).	Interdecadal Pacific Oscillation every 20-30 years, modulates El Nino cycle.	
Aerosols and dust	Large volcanic eruptions		
Solar input		11-year sunspot cycle.	Earth's orbit (20,000year and 41,000, 100,000 year cycles)

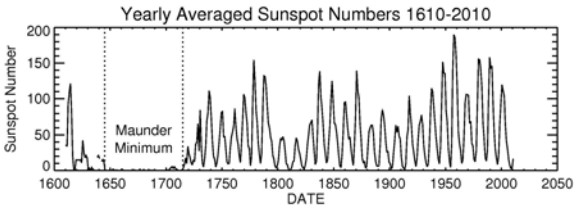
Pacific ocean warming and global temperature rise and fall with El Niño and La Niña

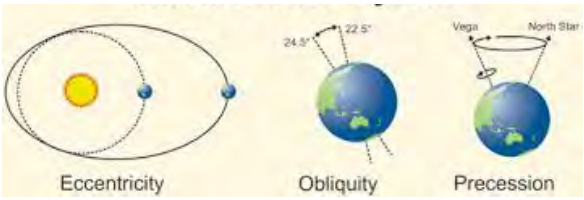


Large volcanic eruptions lead to cooling which can last several years

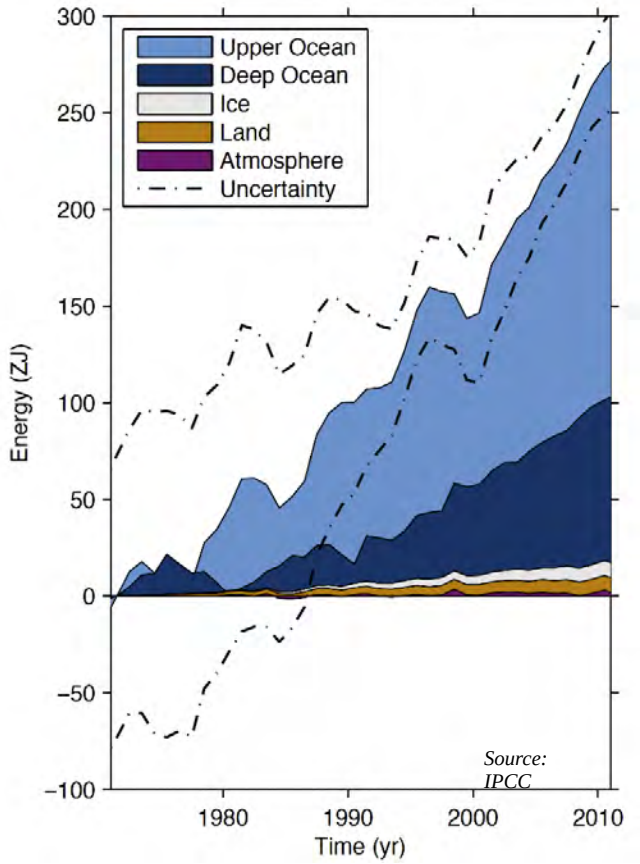
Mt Pinatubo, 1991

Solar output varies – e.g. through sunspots
The Earth's orbit varies – over long timescales



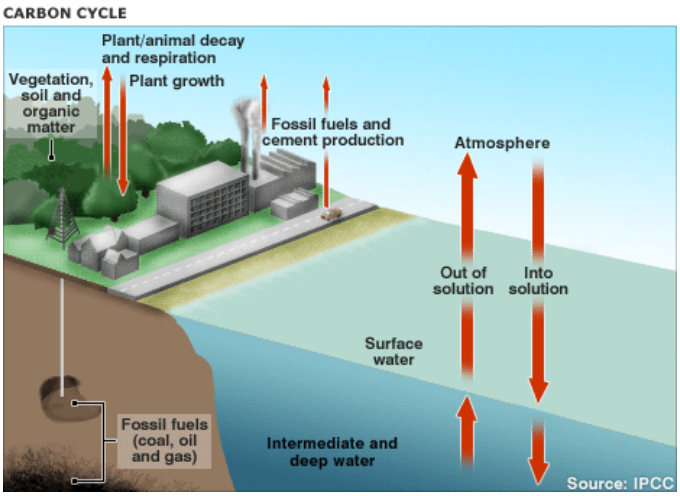


The ocean as a heat sink

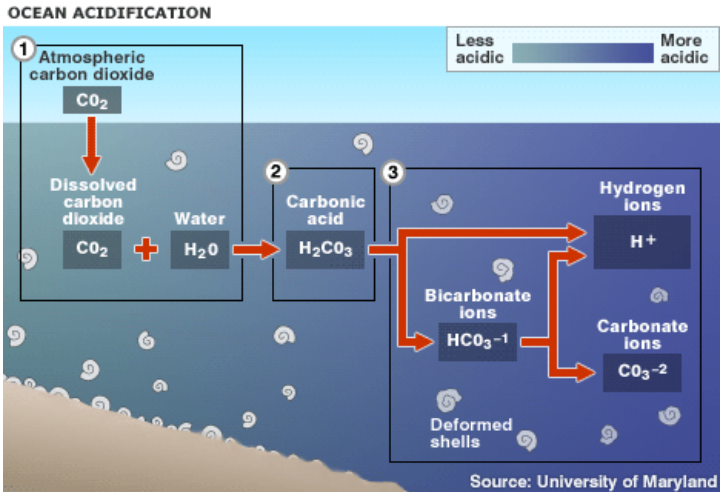


Argo floats – to monitor ocean temperature

CO_2 and the oceans



If atmospheric CO_2 concentrations rise and more CO_2 dissolves in the ocean…



Ocean Acidification has impact independent of rising temperature..

Particularly on species which have carbonate shells as H+ ions react with carbonate ions.
Impact varies dependent on species.

Image: Pteropod – placed in sea water with pH levels projected for 2100, NOAA

Future projections for NZ

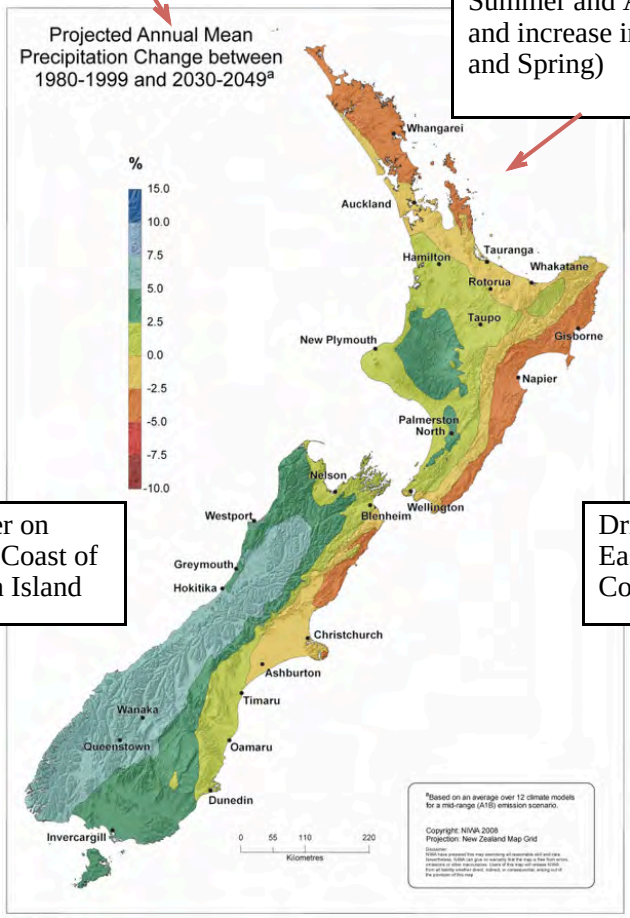
Changes in global and regional temperature affect wind and precipitation patterns.

Changes over the next 30-40 years are expected …

- To be regionally variable
- To be seasonally variable

Shows annual change, but changes by season may be larger

(e.g. in West of North Island the annual change is a net result of a decrease in Summer and Autumn and increase in Winter and Spring)



Wetter on West Coast of South Island

Drier on East Coast

Much of this annual change is caused by increased precipitation in winter and spring

IPCC Reports

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased."

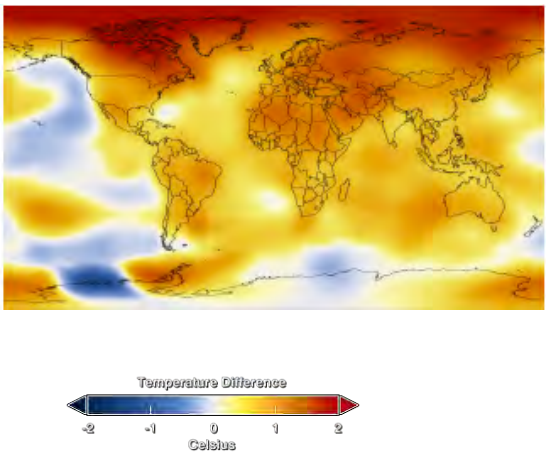
IPCC, WG1 Summary for Policymakers (2013)

Climate change is being observed now…

An 0.8C rise in global mean surface temperatures has occurred since pre-industrial times.

Changes go beyond land surface temperatures alone, for example much of the additional heat (or energy) is stored in the oceans.

Changes are also non-uniform across the globe.

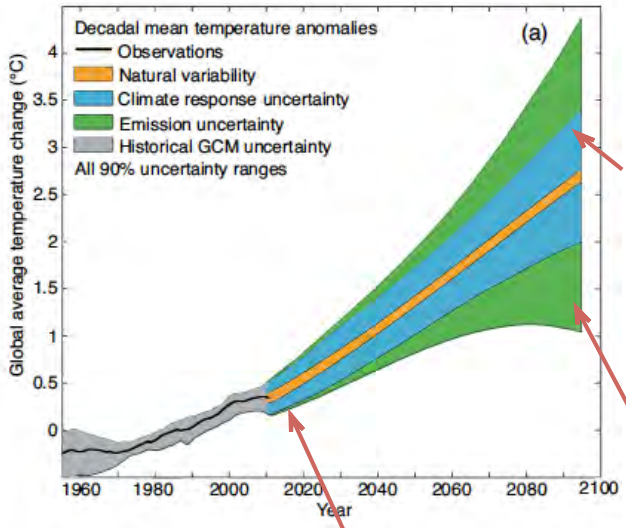


2008-2012

Uncertainty

- Overall uncertainty in projections increases when we look further out into the future
- Exact amount of change for a particular GHG trajectory cannot be projected precisely as they depend on feedbacks and interactions with natural cycles

Regional changes have higher uncertainty than global changes



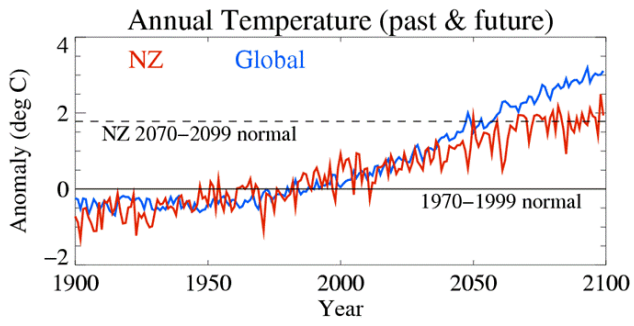
Feedbacks and interactions lead to uncertainty in the climate response for a given greenhouse gas level

By 2100 bulk of uncertainty is due to unknown volume of emissions between now and then

Natural variability is responsible for a significant amount of the uncertainty in the short term

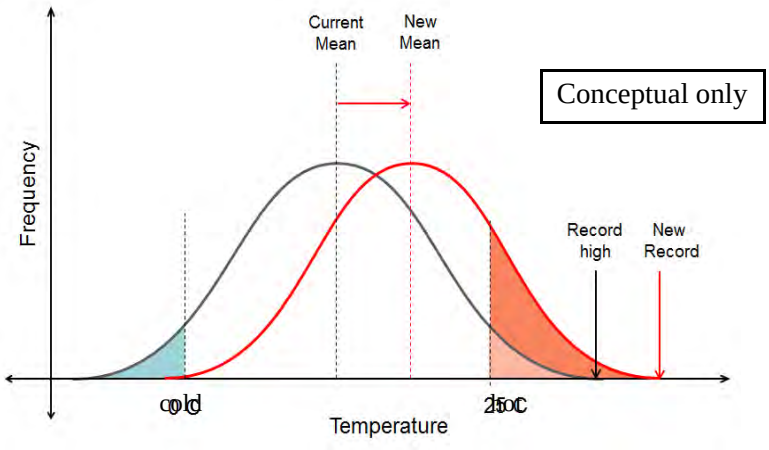
Occurrence of extremes - Temperature

Natural variability from year to year continues with an overlying trend of increasing temperature.



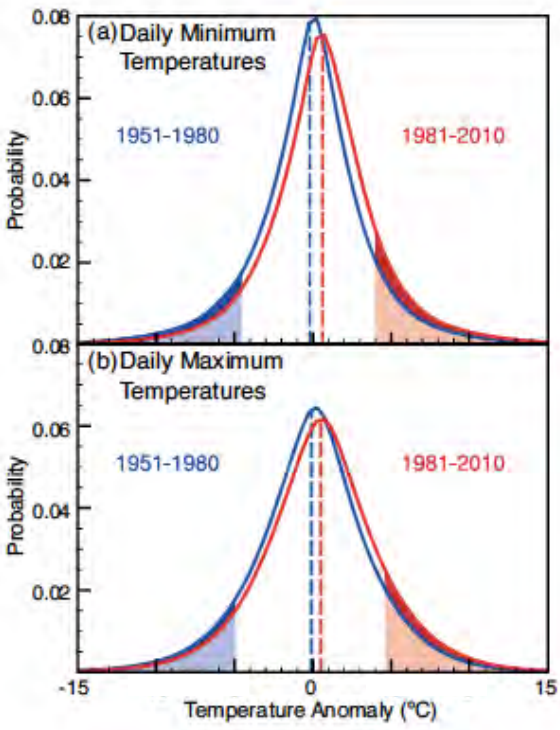
Changes in the mean temperature may appear to be small, but resulting changes at the extremes have significant potential impact:

- New record highs
- More frequent occurrence of hot weather



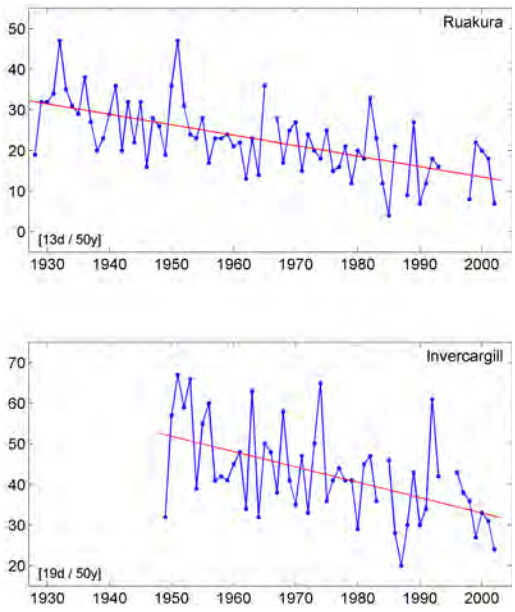
Are we observing such changes globally and nationally?

Global e.g.…



NZ…

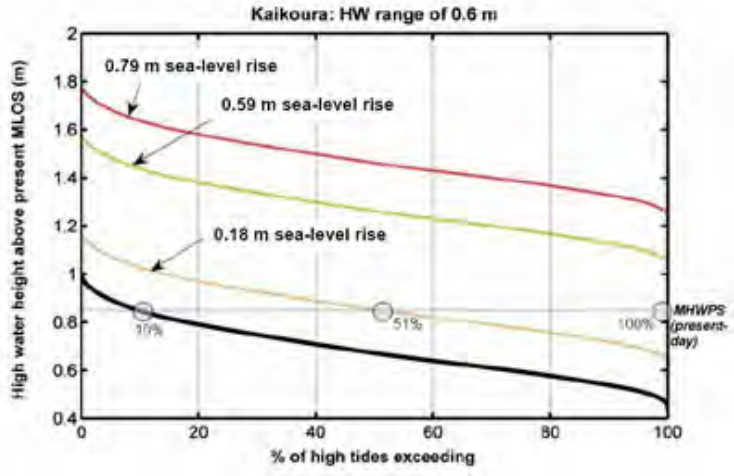
Number of frosts



Extremes – the same principles apply to sea level and rainfall

A small change in the mean sea level for example:

- Increases the number of high tides exceeding the current mean high water spring tide level
- Increases the height of the highest tide



The impact of such changes depends on…

- The magnitude and frequency of events under the new ‘norm’
- Our exposure – e.g. infrastructure built in vulnerable locations

Impact on NZ ecosystems

- Climate change can be expected to impact NZ biodiversity.
- Endemic species may be at higher risk than newly arrived exotics.
- Changes in timing of key seasonal events (such as flowering of crops) may disrupt ecosystems.
- The prevalence and distribution human disease vectors (e.g. mosquitos) may shift as the climate warms

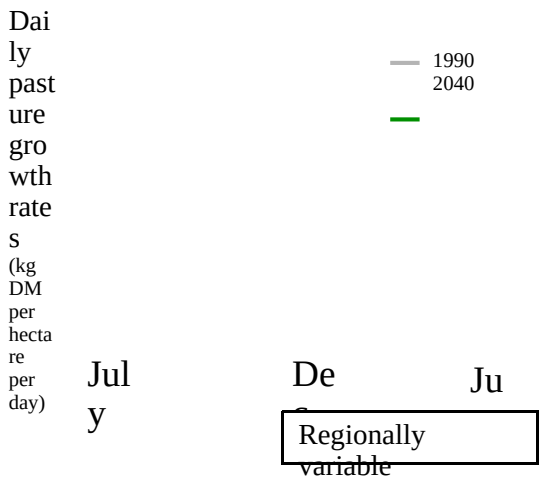
Impact on NZ industry

Climate change has consequences for…

Land based primary industry

- Arable + pastoral farming – e.g. changes in crop and pasture growth rates/quality
- Horticulture – e.g. changing numbers of frosts/year
- Forestry – e.g. increased growth rates, increased fire risk

With planning and adaptation there may be near term opportunities/benefits for some locations/sectors. There are however, significant considerations which are not yet well understood including impact of extreme events, pathogens, and changes beyond 2C.



Impact on NZ industry

Climate change also has consequences for…

Ocean based primary industry

- Fishing – e.g. changes to fish species distribution due to changing temperatures + currents, changes to fish due to pH and temperature change

Tourism

- e.g. ski industry – e.g. changes to amount of snowfall in winter, changes to melt

Energy + Infrastructure

- e.g. changes to rivers and melt with impact on hydro power, factors such as changing temperature also have an impact on demand

Emissions challenge

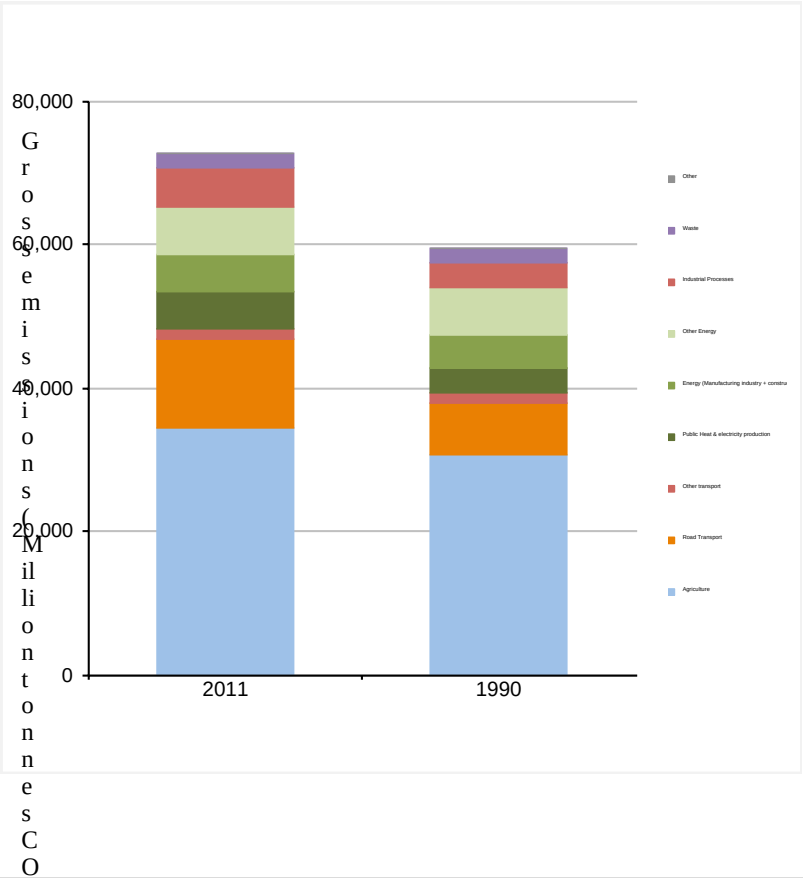
Greenhouse Gas Emissions

Total emissions have increased between 1990 and 2011.

Based on 2011…
Agriculture remains the largest sector emitter for the country – 47% of total emissions.

Transportation is responsible for 19% of NZ's greenhouse gas emissions.

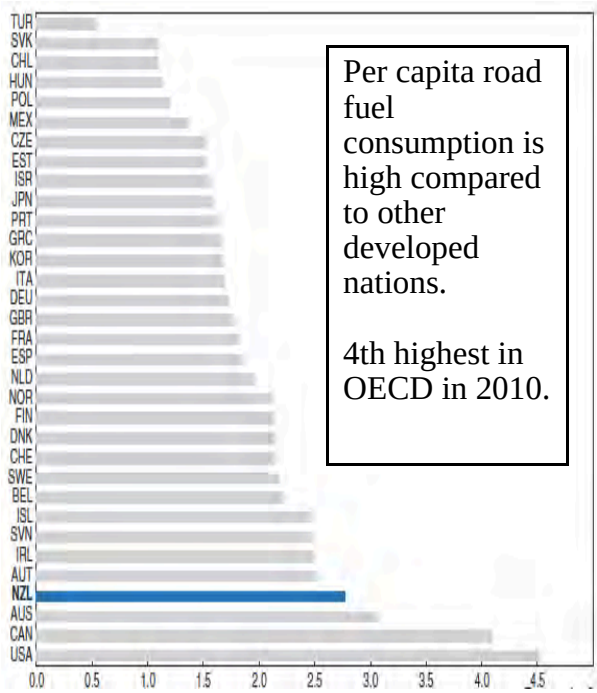
Energy (excluding transport) - 23%.



Gross emissions (Million tonnes CO

Emissions per capita…

Road Transport emissions per capita, 2010

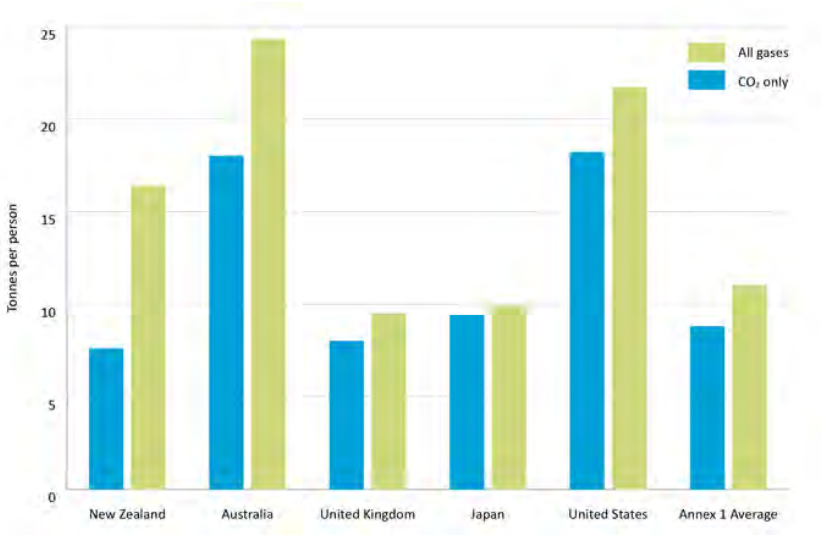


Per capita road fuel consumption is high compared to other developed nations.

4th highest in OECD in 2010.

Tonnes of CO2 per person (per annum)

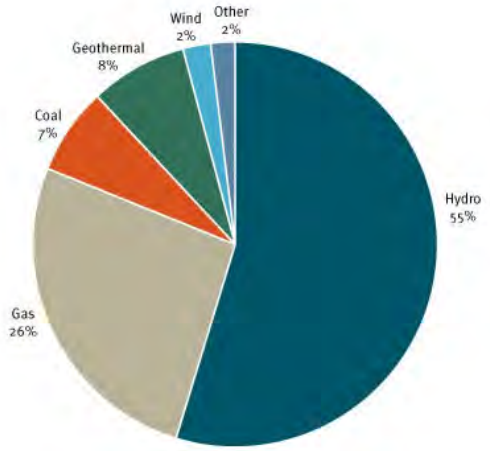
Total emissions per capita



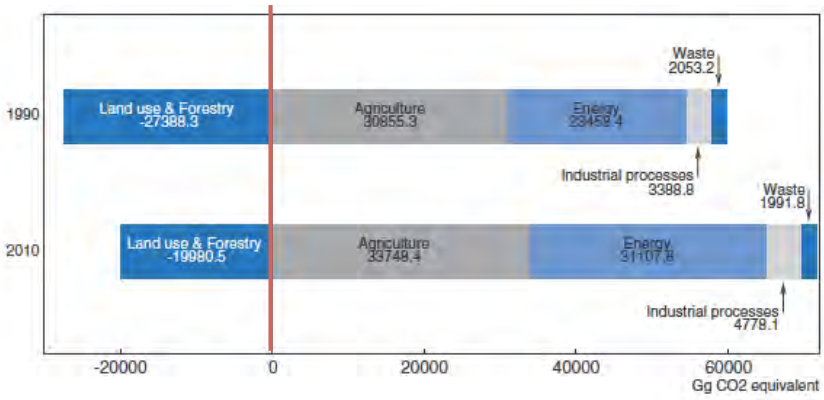
GHG emissions per capita high overall due to agriculture. CO2 emissions per capita overall are comparable to the UK.

Some potential positives..

The electricity grid is low-carbon compared to other countries globally, with over half of NZ electricity generation supplied by hydroelectric power.



Forestation has significant impact, substantially reducing New Zealand's reported net emissions



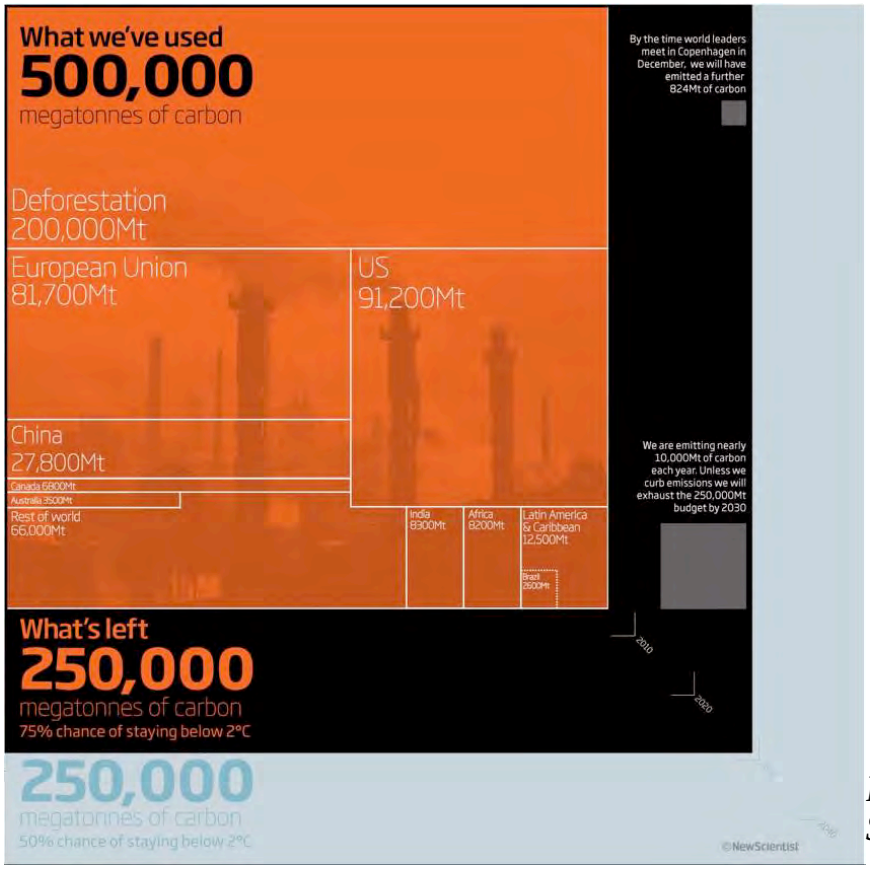
Appendix

Changes for NZ

Geographic zone	Ocean acidification	Temperature & extremes	Wind and circulation	Mean Precipitation	Seasonal & extreme precipitation and drought
All NZ	pH changes are greater in cooler waters.	The midrange of projections is an average temperature increase of 0.9°C by 2040, 2.1°C by 2090.	Increase in strongest winter winds by 2100	Little change in the mean for all NZ but large geographical variation.	Heavier and more frequent extreme rainfalls, but also more droughts. On average, 2 or more extra weeks of drought annually by mid-century for much of North Island and eastern South Island.
North Island	Upwelling areas such as the Hauraki Gulf are more vulnerable to a given change.	Halving or more of the number of frosts by 2100 in the central plateau (to <15 days per year). 40+ extra hot days (>25°C) a year in Auckland by 2100.	Less westerly wind component and more easterly episodes, as tropical zones move south in summer	By 2040 overall precipitation decreases in the east by up to 5% (though seasonally variable), with smaller changes in the west.	West - In summer and autumn rainfall decreases, in winter and spring rainfall increases by up to 5%. East (Gisborne/Hawkes Bay)- decrease in rainfall in winter and spring by up to 5 to 10%.
South Island (incl. Southern Ocean)	Impact in high latitude Southern Ocean expected first, from 2040 onwards.	Frosts expected to be rare in coastal locations by 2050.	More frequent and stronger westerlies during winter and spring	By 2040, increases in the west by 5% and decreases in the east (smaller change)	In winter and spring, more precipitation in the west and south (10% or more increase – responsible for much of the annual change), reduced precipitation in the east (north of Oamaru). Heavier and more frequent extreme rainfalls.

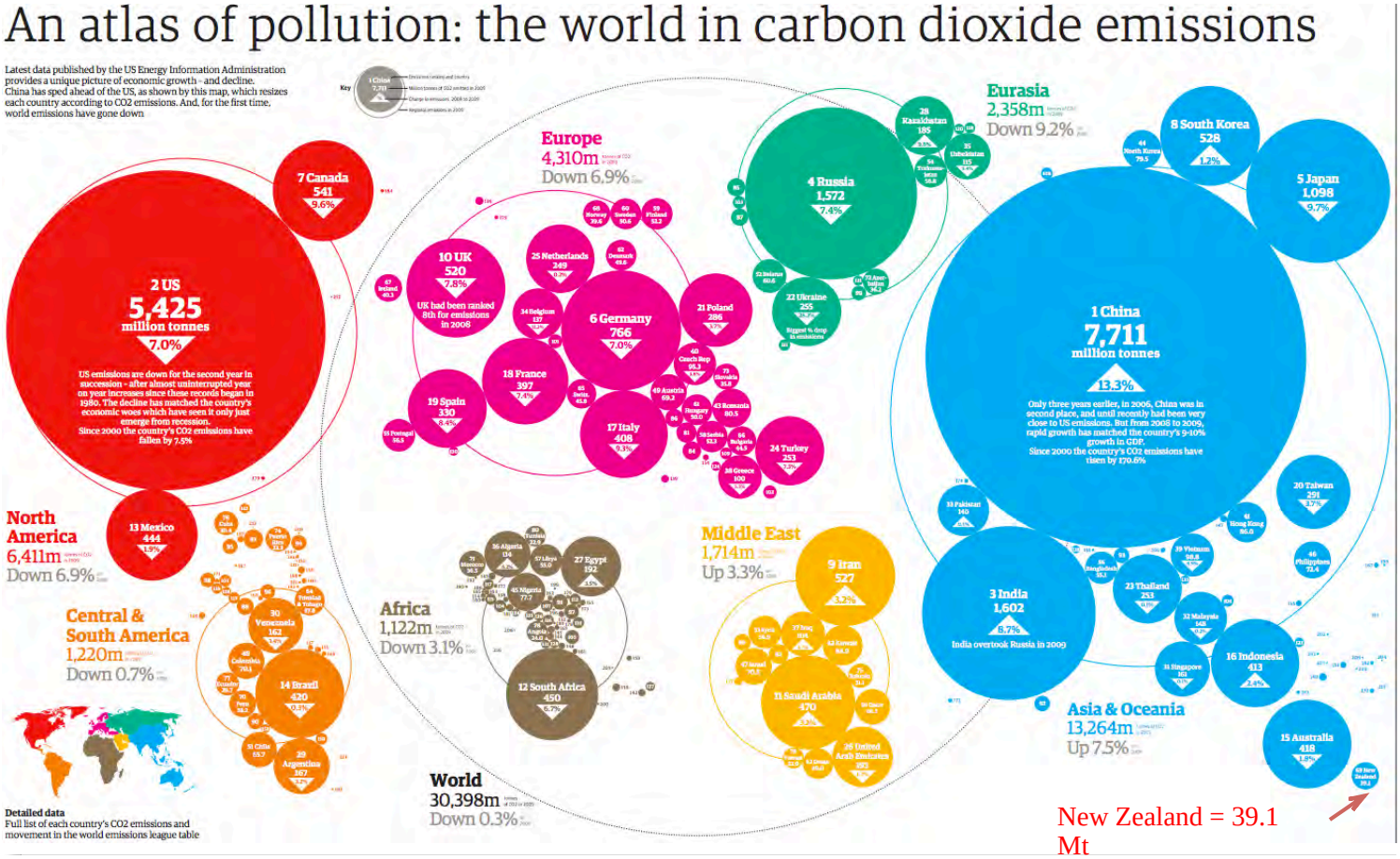
**Where years are quoted, these are the mid-years of a c.20 year average (e.g. 2040 is for 2030-2049)*
Sources: PMCSA Presentations on 8th May, James Renwick and NIWA.

A Global Challenge



Brahic and Pearce, New Scientist, Nov 2009

A Global Challenge

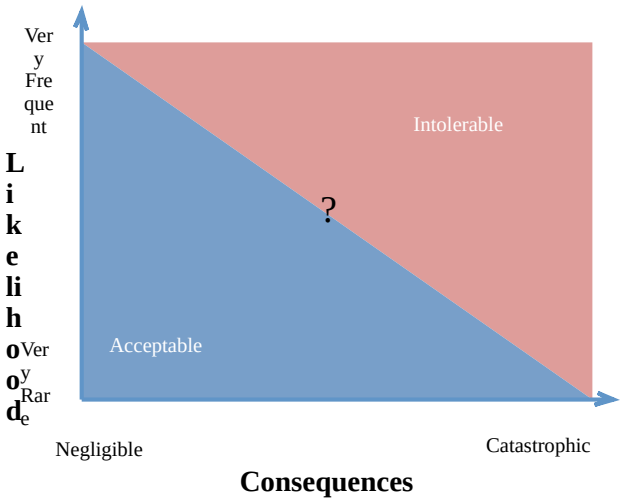


Values

In managing risks and taking action we need to separate the science (what is happening/is projected to happen) from the debate on how we should react to such events.

Some key questions

- What is an acceptable level of climate-related risk to society?
- What are the costs and benefits of adaptation or mitigation compared with other priorities?
- How are different stakeholders affected, (either now or in the future)?

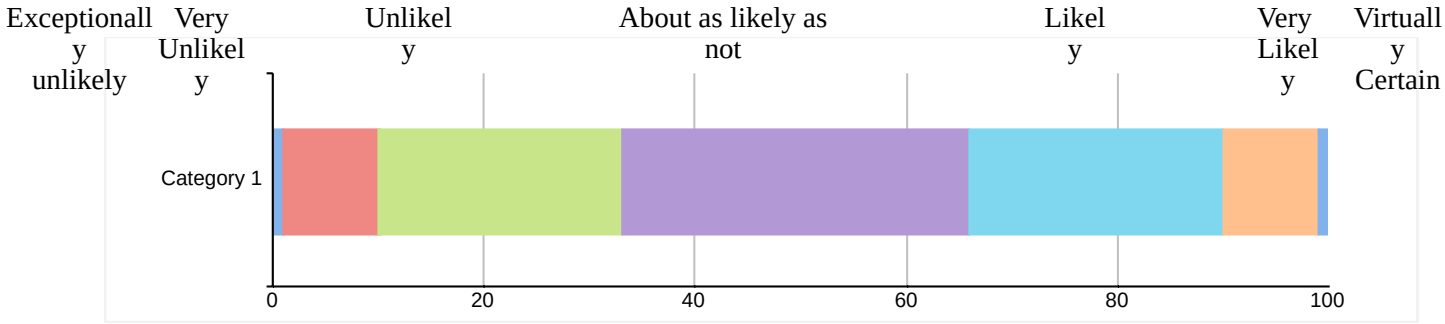


Dealing with uncertainty

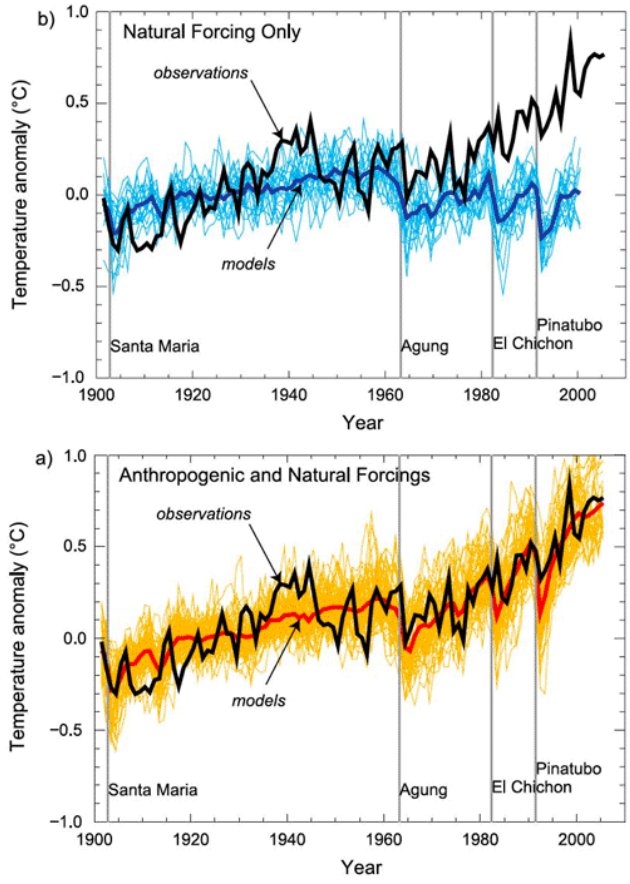
When dealing with uncertainty we have to consider the following components…

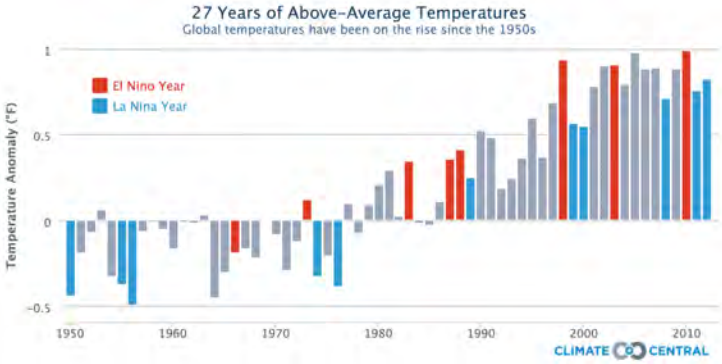
- The **likelihood** of occurrence (e.g. of a temperature increase of 3°C)
- The **consequences** of occurrence (which is partly determined by the present state of the system – or resilience to change)

IPCC – Use the following 'Likelihood' scale for reporting



Natural ‘forcing’ cannot however explain recent trends..





Variability and the ‘hiatus’